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(54) Aluminum interconnections

(57) A method is provided of enhancing the aluminum interconnect properties in very fine metalization patterns interconnecting integrated circuits, to improve the texture and electromigration resistance of aluminum in thin films. Enhanced performance can be obtained by forming a smooth oxide layer in situ, or by surface conditioning a previously formed oxide layer in an appropriate manner to provide the requisite surface smoothness. The aluminum microstructure is then refined by hot deposition or ex-situ heat treatment.

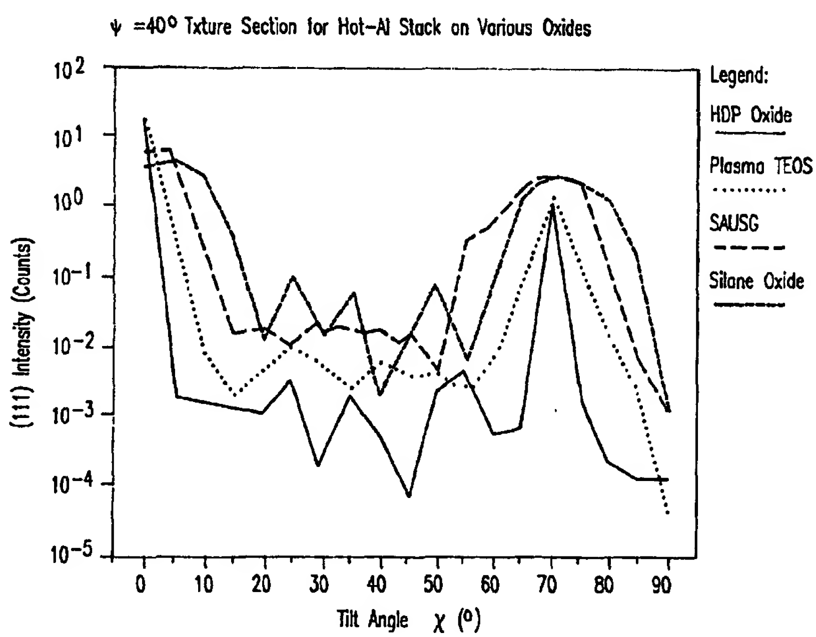

FIG.1

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Oxides 4, metal lines were formed on each type of oxide studied. The metal lines were formed in th same manner on each oxide substrat by sequential sputter-d position of a 200Å titanium layer; then a 2000Å AlCuSi alloy (50°C), and finally a 5500Å AlCu (525°C) layer, in that sequence, using a multichamber dc-magnetron sputtering system having a base pressure of about 2 x 10^{-8} Torr. The metal lines patterns were formed by conventional photolithographic methods. Th insulator/metal film structures were annealed at 400°C in flowing N_2 (90%)/H_2(10%) ambi nt for 20 minutes.

All insulator/aluminum film structures were studied directly after deposition and after annealing. The reflectivity and resistivity properties of the aluminum-containing film were measured and are summarized in Table 3.

Table 3

Oxide Type	M1 Etch	C1 Etch	CMP	Reflectivity (%),	σ(%)	Rs (mΩ/sq),	σ(%)
Silane Oxide 1	X	-	-	.695	4.73	.04248	3.59
Silane Oxide 2	-	X	-	.853	1.21	0.04048	2.11
Silane Oxide 3	-	-	X	.880	0.41	.03991	1.81
Silane Oxide 4	-	-	-	.728	3.62	.04142	2.30
Plasma TEOS Oxide 1	X	-	-	.884	0.69	.03999	2.06
Plasma TEOS Oxide 2	-	X	-	.845	0.73	.04052	1.84
Plasma TEOS Oxide 3	-	-	X	.882	0.45	0.4001	1.97
Plasma TEOS Oxide 4	-	-	-	.884	0.40	.04002	1.90

Again, it is evident from the results summarized in Table 3 that plasma TEOS yields generally superior films to silane oxide. However, as disclosed herein, less costly silane oxide can be improved to provide equivalent performance by CMP or the C1 etch process.

While the present invention has been illustrated in terms of TEOS derived-oxides, silane oxides, high density plasma oxides, it will be understood that other oxide forming techniques can be utilised, such as thermally grown oxide. Also, other insulator substrate materials, and not merely oxides, that can be imbued with smooth surfaces can also be used as the underlayer for the aluminum films to yield similar results in favorably controlling the aluminum texture for elctromigration performance and metal line reliability in an aluminum (alloy) layered interconnection.

Claims

1. A method of making an aluminum-based interconnection on a semiconductor substrate in which the interconnection resists electromigration, comprising the steps of:

   (a) forming an insulator layer having a surface roughness; and

   (b) forming an aluminum-containing layer on said insulator layer;

   wherein the surface roughness of said insulator layer is provided sufficiently low in step (a) to form said aluminum-containing layer in step (b) with an increased resistance to electromigration.

2. The method of claim 1, wherein said aluminum-containing layer is selected from the group consisting of pure aluminum and aluminum alloys.

3. The method of claim 2, wherein said aluminum is an aluminum alloy selected from the group consisting of Al_3Ti, Al-Ti, Al-Ti-Si, Al-Cu, AlSi, Al-Si-Cu, and Ti/Al-Cu.

4. The method of any preceding claim, wherein said insulator layer is an oxide layer.

5. The method of claim 4, wherein said oxide layer is a silicon oxide layer.

6. The method of claim 4, wherein said oxide lay r is formed in step (a) by a procedure selected from the group